USER MANUAL

NI ISM-7411/7412

Ethernet Integrated Stepper

This manual describes the NI ISM-7411 and the NI ISM-7412 integrated steppers. It describes electrical and mechanical characteristics of the devices, as well as I/O functionality.

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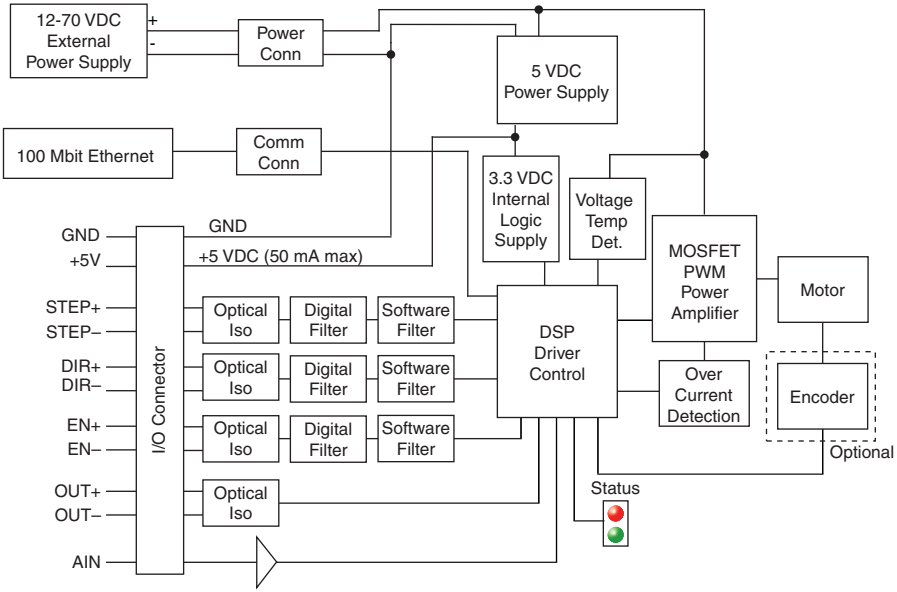
NATIONAL INSTRUMENTS

Figure 1. Block Diagram



Getting Started

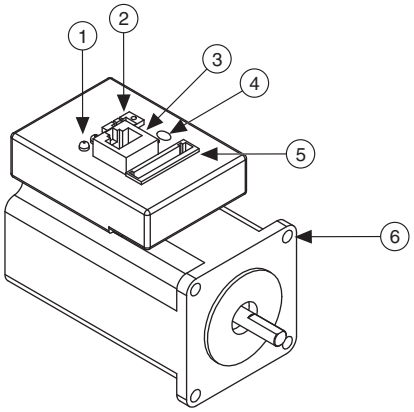
You will need the following items to get started with your NI ISM-7411/7412:

- ☐ 12 VDC to 70 VDC power supply. NI PS-12 (NI part number 748906-01) or NI PS-13 (NI part number 748907-01) recommended.
- ☐ Tool for inserting wires into the connector
- ☐ A PC running Microsoft Windows 8.1/8/7/Vista/XP, with an available Ethernet port
- ☐ A CAT5 Ethernet cable (not included)
- ☐ NI Stepper Configuration Utility, available from `ni.com/downloads`

Refer to *Choosing a Power Supply* for more information.

Figure 2 shows an overview of the connectors on the NI ISM-7411/7412 integrated stepper.

Figure 2. NI ISM-7411/7412 Integrated Stepper Connectors



1	Status LED	3	I/O Connector
2	DC Power Connector	4	Rotary Switch
3	Ethernet Port	4	Mounting Hole

Mounting the NI ISM-7411/7412

Mount your NI ISM-7411/7412 using four #6 or #8 screws. Securely fasten the NI ISM-7411/7412 to a smooth, flat metal surface to conduct heat away from the motor. To prevent overheating, forced airflow from a fan may be required. Refer to the *Heating* section for more information.

Caution Never use your NI ISM-7411/7412 in a space where there is no airflow or where other devices cause the surrounding air to be higher than 40 °C.

Caution Never put the NI ISM-7411/7412 where it can get wet or where metal or other electrically conductive particles can contact the circuitry.

Caution Always provide air flow around the drive. When mounting multiple NI ISM-7411/7412 integrated steppers near each other, maintain at least one half inch of space between devices.

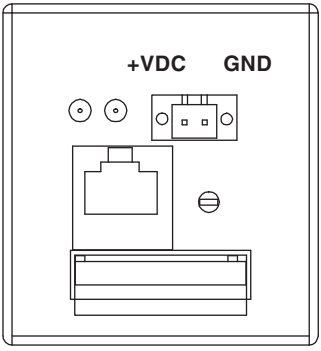
Connecting the Power Supply

Refer to *Choosing a Power Supply* for more information.

1. Use 1.02 mm to 0.81 mm diameter (18-20 AWG) gauge stranded wire for connections.
2. Connect the power supply positive (+) terminal to the connector terminal labeled V+.
3. Connect power supply negative (-) terminal to the connector terminal labeled V- .

The NI ISM-7411/7412 contains an internal fuse that connects to the power supply positive (+) terminal. This fuse is not user-replaceable. If you want to install a user-replaceable fuse in your system, install a fast-acting 4 A fuse in line with the positive (+) power supply lead. Figure 3 shows the NI ISM-7411/12 connections.

Figure 3. Orientation of the NI ISM-7411/7412 Power Connector



Caution Do not reverse the wires. Reverse connection will damage your drive and void your warranty.

When you rapidly decelerate a load from a high speed, much of the kinetic energy of that load transfers back to the power supply. This transfer can trigger the overvoltage protection of a switching power supply, causing it to shut down. Unregulated power supplies generally do not have overvoltage protection and have large capacitors for storing energy coming back from the drive. NI offers the SMD-7700 regeneration clamp, part number 748908-01, to solve this problem.

Choosing a Power Supply

NI offers two power supplies for the NI ISM-7411/7412:

- NI PS-12 (24 V, 6.3 A)
- NI PS-13 (48 V, 6.7 A)

Voltage

Your motor can provide optimum performance between 24 and 48 volts DC. Choosing the voltage depends on the performance needed and thermal performance. Higher voltages will give higher speed performance but will cause the motor to operate at higher temperatures. Using power supplies with voltage outputs that are near the drive maximum may reduce the operational duty-cycle significantly. Refer to the charts in *Reference Materials* to determined thermal performance at different power supply voltages.

Note If you choose an unregulated power supply, ensure the no-load voltage of the supply does not exceed 60 VDC.

Current

The power supply current required by the motor at various voltages is shown in the following charts. The supply current flowing into the motor may be less than the motor phase current, because the motor amplifier converts high voltages and low currents from the DC power supply into the higher current and lower voltage required by the motor. Using a higher voltage power supply will increase high speed torque, but will also increase motor heating.

The current draw is significantly different at higher speeds depending on the motor torque load. Estimating your current needs may require a good analysis of the load the motor will encounter.

Figure 4. NI ISM-7411 Behavior, 12V Power Supply

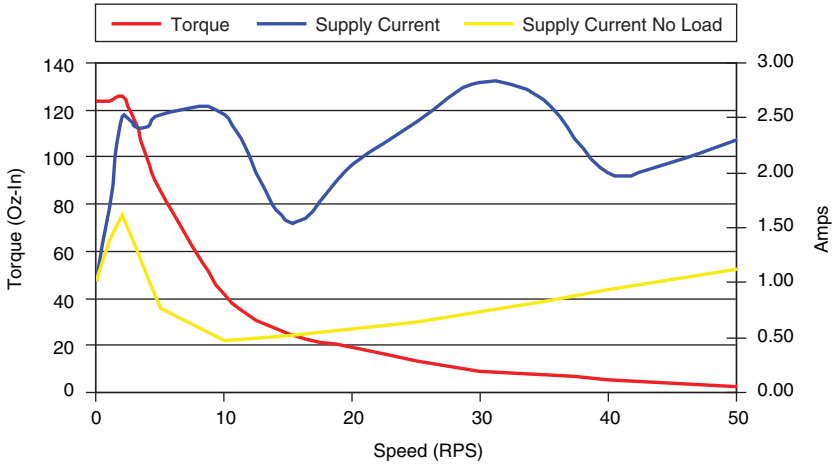


Figure 5. NI ISM-7411 Behavior, 24 V Power Supply

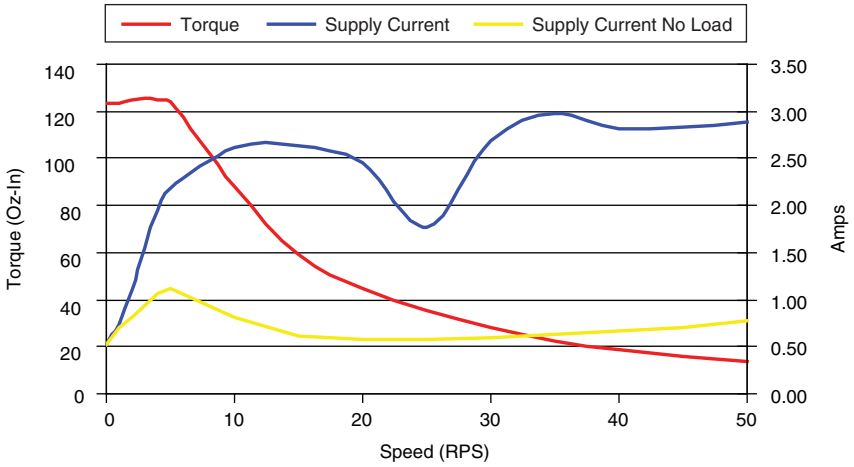


Figure 6. NI ISM-7411 Behavior, 48 V Power Supply

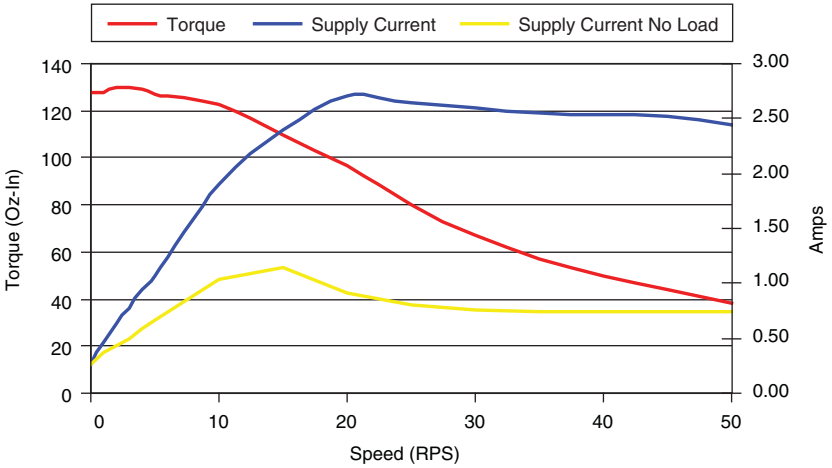


Figure 7. NI ISM-7411 Behavior, 70V Power Supply

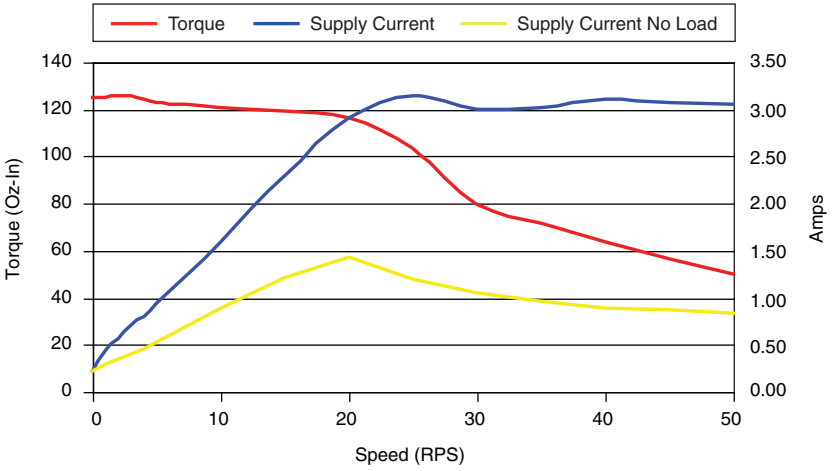


Figure 8. NI ISM-7412 Behavior, 12V Power Supply

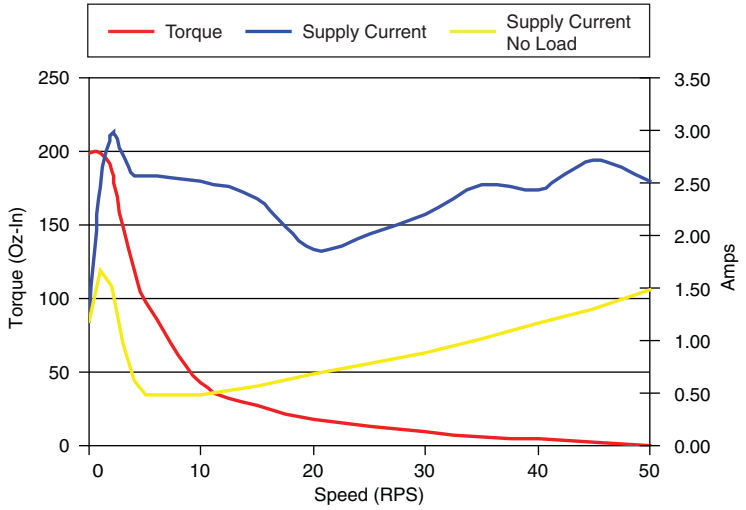


Figure 9. NI ISM-7412 Behavior, 24 V Power Supply

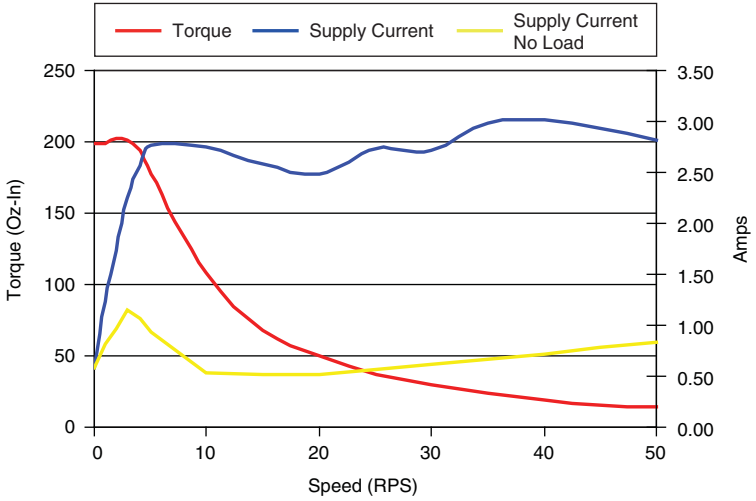


Figure 10. NI ISM-7412 Behavior, 48 V Power Supply

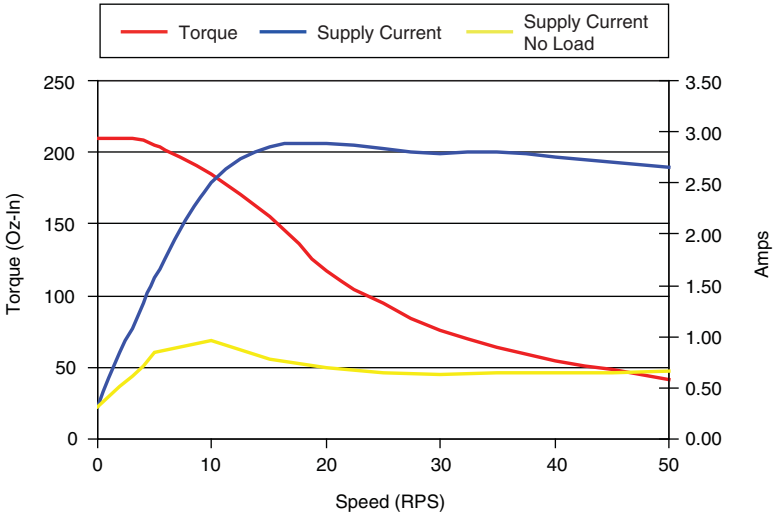
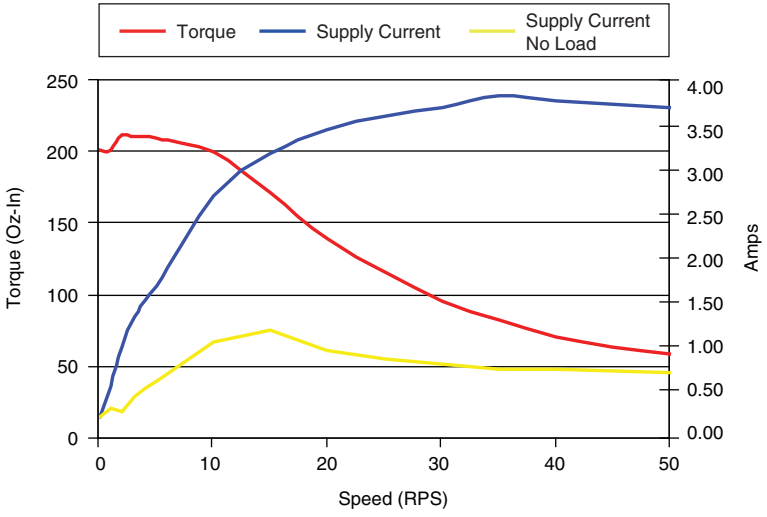


Figure 11. NI ISM-7412 Behavior, 70V Power Supply



If you plan to use a regulated power supply, you may encounter a problem with regeneration. If you rapidly decelerate a load from a high speed, much of the kinetic energy of that load is transferred back to the power supply. This can trip the overvoltage protection of a switching power supply, causing it to shut down. Unregulated power supplies are better suited for applications with significant regeneration as they generally do not have overvoltage protection and have large capacitors for storing energy coming back from the drive. Refer to *Connecting the Power Supply* for more information.

Connecting the Device Using Ethernet

This process requires three steps:

1. Physically connect the device to your network (or directly to the PC).
2. Set the drive IP address.
3. Set the appropriate networking properties on your PC.

Your device includes a 16 position rotary switch for setting its IP address. The factory default address for each switch setting is shown in the table below.

Table 1. IP Address Rotary Switch Settings

Position	IP Address	
0	10.10.10.10	
1	192.168.1.10	
2	192.168.1.20	
3	192.168.1.30	
4	192.168.0.40	
5	192.168.0.50	
6	192.168.0.60	
7	192.168.0.70	
8	192.168.0.80	
9	192.168.0.90	
A	192.168.0.100	
B	192.168.0.110	
C	192.168.0.120	
D	192.168.0.130	
E	192.168.0.140	
F	DHCP	

The IP address corresponding to positions 1 through E can be changed using the NI Stepper Configuration Utility software (use Quick Tuner for servo drives). Setting 0 is always 10.10.10.10, the universal recovery address.

Setting F is DHCP, which commands the device to get an IP address from a DHCP server on the network. The IP address automatically assigned by the DHCP server may be dynamic or static depending on how the administrator has configured DHCP. The DHCP setting is reserved for advanced users.

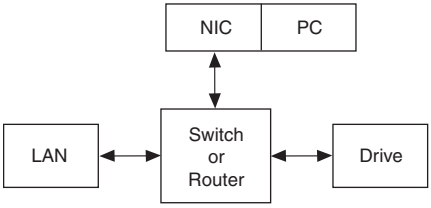
Your PC, or any other equipment that you use to communicate with the device, will also have a unique address.

On the device switch settings 1 through E use the standard class B subnet mask (i.e. 255.255.0.0). The mask for the universal recovery address is the standard class A (i.e. 255.0.0.0).

Option 1: Connect a Drive to Your LAN

If you have a spare port on a switch or router and if you are able to set your device to an IP address that is compatible with your network, and not used by anything else, this is a simple way to get connected. This technique also allows you to connect multiple devices to your PC. If you are on a corporate network, check with your system administrator before connecting anything new to the network. He or she should be able assign you a suitable address and help you get going.

Figure 12. Example Network Configuration



Many networks use dynamic addressing where a DHCP server assigns addresses on demand. The address you choose for your device might get assigned to something else by the DHCP server at another time.

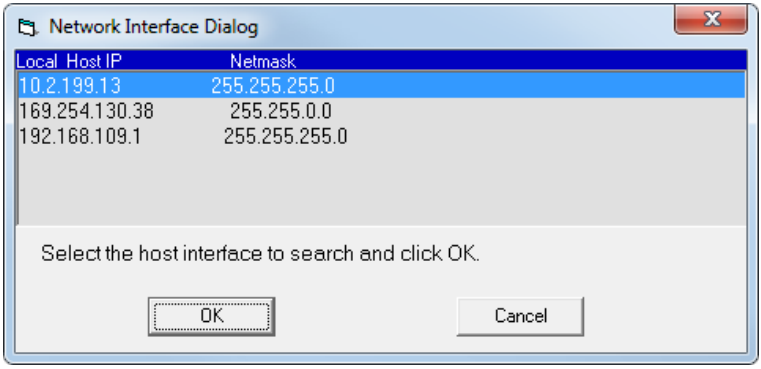
Once you've chosen an appropriate IP address for your device, set the rotary switch according to the address table above. If none of the default addresses are acceptable for your network, you can enter a new table of IP addresses using the NI Stepper Configuration Utility. If your network uses addresses starting with `192.168.0`, the most common subnet, you will want to choose an address from switch settings 4 through E. Another common subnet is `192.168.1`. If your network uses addresses in this range, the compatible default selections are 1, 2 and 3. If your PC address is not in one of the above private subnets, you will have to change your subnet mask to `255.255.0.0` in order to communicate with your device. To change your subnet mask:

1. Open **Network Connections**.
   a. **Windows 8.1/8/7/Vista**—Open **Control Panel**. From the icon view, open **Network and Sharing Center**, then click **Change Adapter Settings**.
   b. **Windows XP**—Right-click **My Network Places** and select **Properties**.
2. Right-click your network interface card (NIC) and select **Properties**.
   a. **Windows 8.1/8/7/Vista**—Scroll down and select **(TCP/IPv4)**, then click **Properties**.
   b. **Windows XP**—Scroll down and select **Internet Properties (TCP/IP)**, then click **Properties**.
3. If the **Obtain an IP address automatically** option is selected, your PC is getting an IP address and a subnet mask from the DHCP server. Cancel this dialog and proceed to the *Using DHCP* section.
4. If the option **Use the following IP address** is selected, change the subnet mask to `255.255.0.0` and click **OK**.

Using DHCP

If you want to use your device on a network where all or most of the devices use dynamic IP addresses supplied by a DHCP server, set the rotary switch to "F". When the device is connected to the network and powered on, it will obtain an IP address and a subnet mask from the server that is compatible with your PC. However, you will not know what address the server assigns to the device. The NI Stepper Configuration Utility can find your device using the **Drive Discovery** feature, as long as your network isn't too large. When the device connected to the network is powered on, select **Drive Discovery** from the **Drive** menu to launch the **Network Interface Dialog** dialog box.

Figure 13. Network Interface Dialog Dialog Box



Normally, Drive Discovery only detects one network interface card (NIC), and selects it automatically. If you are using a laptop and have both wireless and wired network connections, a second NIC may appear. Please select the NIC that you use to connect to the network to which you've connected your device. Then click **OK**. Drive Discovery notifies you as soon as it has detected a device.

If you think this is the correct device, click **Yes**. If you are not sure, click **Not Sure** and Drive Discovery will look for additional devices on you network. Once you have told Drive Discovery which device is yours, it automatically enters the device IP address in the IP address text box so that you are ready to communicate.

Option 2: Connect a device Directly to Your PC

1. Connect one end of a CAT5 Ethernet cable into the LAN card (NIC) on your PC and the other into the device. You don't need a special crossover cable; the device automatically detects the direct connection and make the necessary physical layer changes.
2. Set the IP address on the device to `10.10.10.10` by setting the rotary switch to position 0.
3. To set the IP address of your PC:
   a. **Windows 8.1/8/7/Vista**—Open **Control Panel**. From the icon view, open **Network and Sharing Center**, then click **Change Adapter Settings**.
   b. **Windows XP**—Right-click **My Network Places** and select **Properties**.

4. Right-click your network interface card (NIC) and select **Properties**.
   a. **Windows 8.1/8/7/Vista**—Scroll down and select **(TCP/IPv4)**, then click **Properties**.
   b. **Windows XP**—Scroll down and select **Internet Properties (TCP/IP)**, then click **Properties**.
5. Select **Use the following IP address** and enter the address `10.10.10.11`. This assigns your PC an IP address that is on the same subnet as the device. Windows directs any traffic intended for the device's IP address to this interface card.
6. Next, enter the subnet mask as `255.255.255.0`.
7. Leave **Default gateway** blank. This prevents your PC from looking for a router on this subnet.

Note Because you are connected directly to the device, anytime the device is not powered you will receive a small message bubble in the corner of your screen saying "The network cable is unplugged."

Option 3: Use Two Network Interface Cards (NICs)

This technique allows you to keep your PC connected to your LAN, but keeps the device off the LAN, preventing possible IP conflicts or excessive traffic.

1. If you use a desktop PC and have a spare card slot, install a second NIC and connect it directly to the device using a CAT5 cable. You don't need a special "crossover cable"; the device will automatically detect the direct connection and make the necessary physical layer changes.
2. If you use a laptop and only connect to your LAN using wireless networking, you can use the built-in RJ45 Ethernet connection as your second NIC.
3. Set the IP address on the device to `10.10.10.10` by setting the rotary switch to position 0.
4. To set the IP address of the second NIC:
   a. On Windows XP, right-click **My Network Places** and select **Properties**.
   b. On Windows 7, click **Computer**. Scroll down the left pane until you see **Network**. Right-click and select **Properties**. Select **Change adapter settings**.
5. Right-click your network interface card (NIC) and select **Properties**.
   a. Scroll down until you see **Internet Properties (TCP/IP)**. Select this item and click the **Properties** button.
   b. On Windows 7 and Vista, look for **(TCP/IPv4)**.
6. Select **Use the following IP address** and enter the address `10.10.10.11`. This assigns your PC an IP address that is on the same subnet as the device. Windows directs any traffic intended for the device's IP address to this interface card.
7. Next, enter the subnet mask as `255.255.255.0`.
8. Leave **Default gateway** blank. This prevents your PC from looking for a router on this subnet.

Note Because you are connected directly to the device, anytime the device is not powered you will receive a small message bubble in the corner of your screen saying "The network cable is unplugged."

Connecting Input Signals

The NI ISM-7411/7412 has three digital inputs and one analog input:

- **STEP**—High-speed digital input for step pulse commands, 5 V to 24 V logic
- **DIR—** High-speed digital input for the direction signal, 5 V to 24 V logic
- **EN—** 5 V to 24 V input for commanding the removal of power from the motor
- **AIN—** Reserved

Figure 14. Connector Pin Diagram

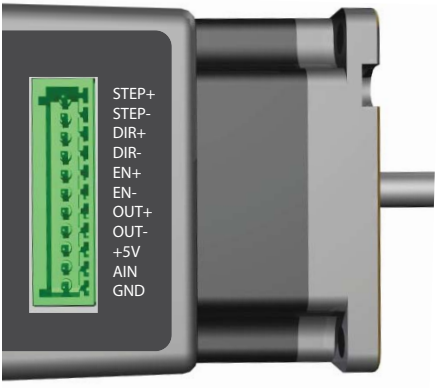
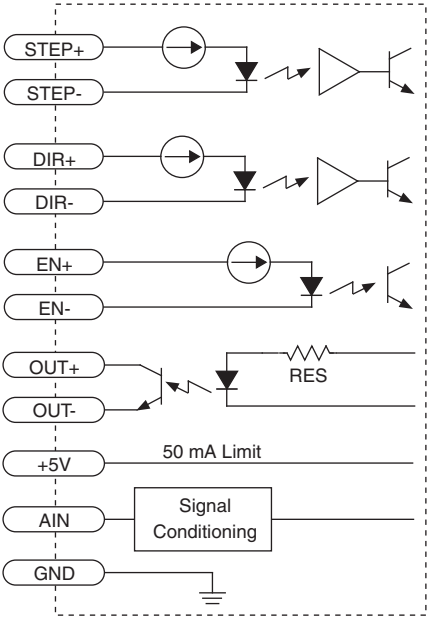


Figure 15. Internal Circuit Diagram



Connection Examples: STEP & DIR

Figure 16. Connecting to Indexer with Sourcing Outputs

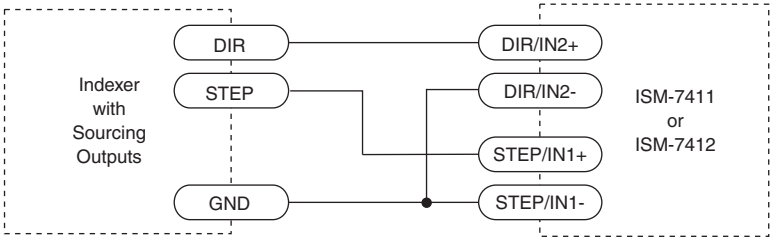


Figure 17. Connecting to Indexer with Sinking Outputs

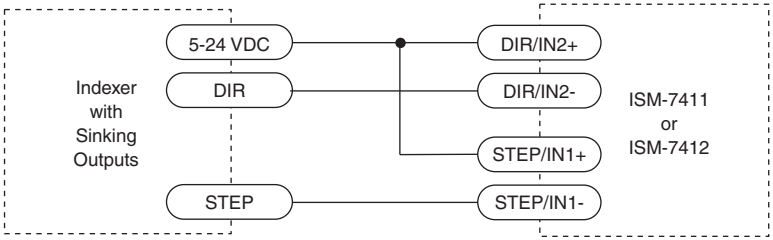


Figure 18. Connecting to Indexer with Differential Outputs

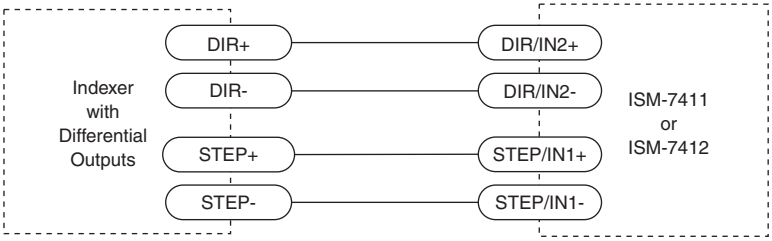
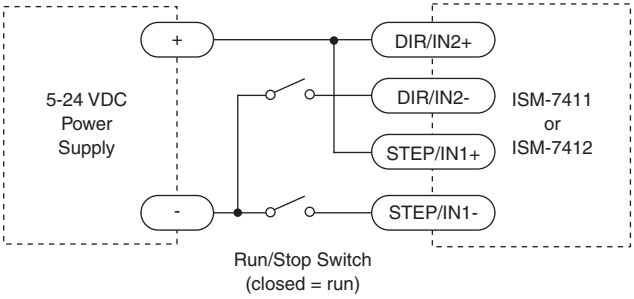


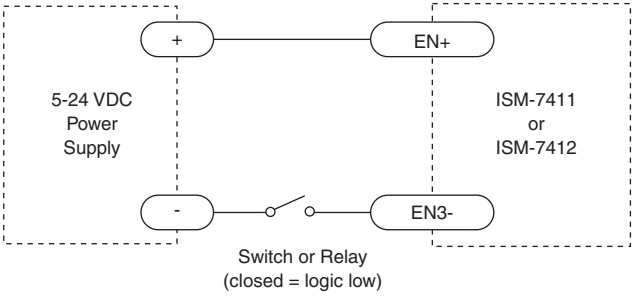
Figure 19. Using Mechanical Switches



Connection Examples: EN

Connecting the Enable input as shown in Figure 20 causes the drive to disable when the relay is closed and enable when the relay is open.

Figure 20. Connecting an Input to a Switch or Relay



Connecting the Enable signal as shown in Figures 21 and 22 causes the drive to disable when the proximity sensor activates.

Figure 21. Connecting an NPN Type Proximity Sensor to an Input

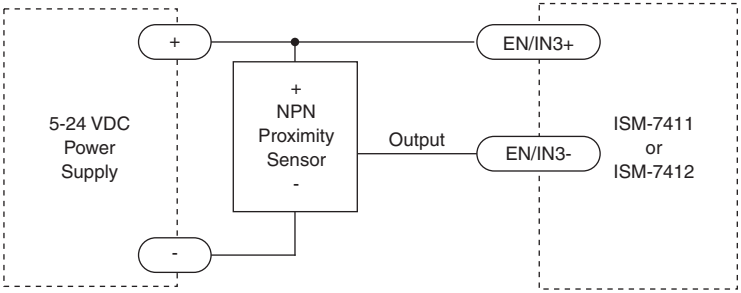
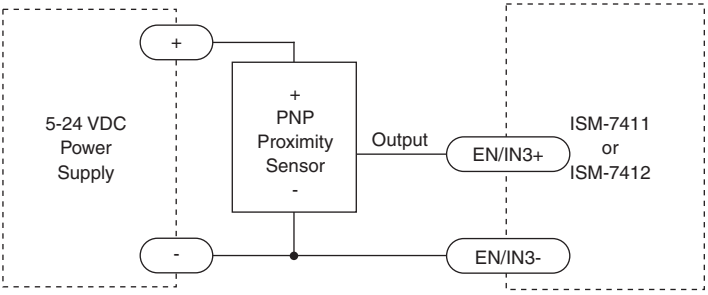


Figure 22. Connecting a PNP Type Proximity Sensor to an Input



Note When the proximity sensor activates, the input closes.

Connecting the Digital Output

The NI ISM-7411/7412 has a digital output labeled OUT. You can use this output to automatically control a motor brake or signal fault conditions. You can also use it to drive LEDs, relays, and the inputs of other electronic devices like PLCs. The positive collector (OUT+) and negative emitter (OUT-) terminals of the output transistor are available at the connector. This allows you to configure the output for current sourcing or sinking.

Diagrams of each type of connection follow.

Caution Do not connect the output to more than 30 VDC. The current through the output terminal must not exceed 80 mA.

Figure 23. Sinking Output

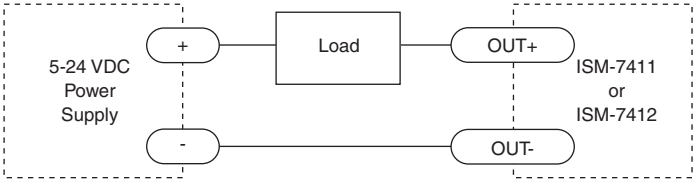


Figure 24. Sinking Output with PLC

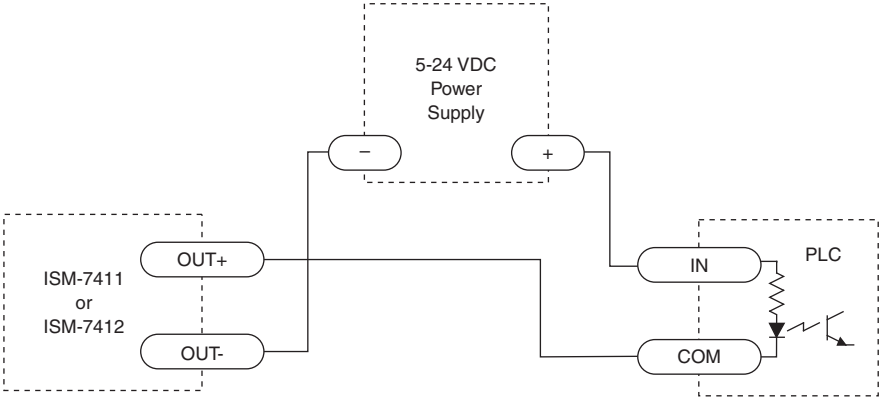


Figure 25. Sourcing Output

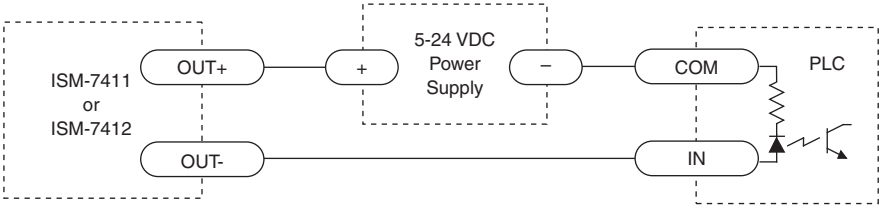
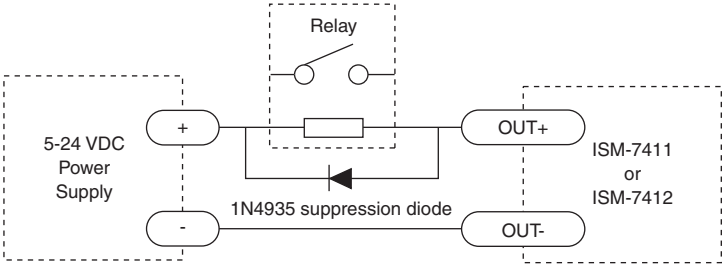


Figure 26. Driving a Relay



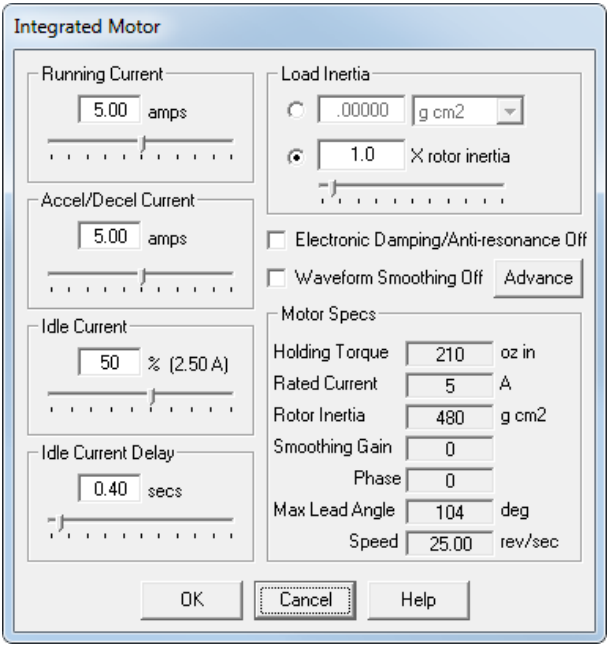
Configuring the NI ISM-7411/7412

The NI ISM-7411/7412 is configured in software with the NI Stepper Configuration Utility, available at `ni.com/downloads`. When you have located your device with the utility, you can configure various aspects of the motor performance and control for your application.

Motor

From the NI Stepper Configuration Utility home screen, click the **Motor** icon to open the configuration window and configure the following settings:

Figure 27. NI Stepper Configuration Utility Configuration Window



Running Current

Seting the Running Current to 100% will achieve maximum torque. However, under some conditions you might want to reduce the current to save power or lower motor temperature. This is important if the motor is not mounted to a surface that will help it conduct heat away or if you expect the ambient temperature to be high.

Step motors produce torque in direct proportion to current, but the amount of heat generated is roughly proportional to the square of the current. If you operate the motor at 90% of rated current, the motor provides 90% of the rated torque and approximately 81% as much heat. At 70% current, the torque is reduced to 70% and the heating to about 50%.

Accel/Decel Current

The motor requires the most torque when accelerating and decelerating a load. You may need to set the Accel\Decel Current higher than the Running Current to account for these peaks.

Idle Current/Idle Current Delay

You can reduce motor heating and power consumption by lowering the motor current when it is not moving. The NI ISM-7411/7412 automatically lowers the motor current when it is idle for longer than the time specified by Idle Current Delay.

The default 50% idle current setting lowers the holding torque to 50% of the specified Running Current, which is enough to prevent the load from moving in most applications. You can adjust this value to account for your load and heating requirements.

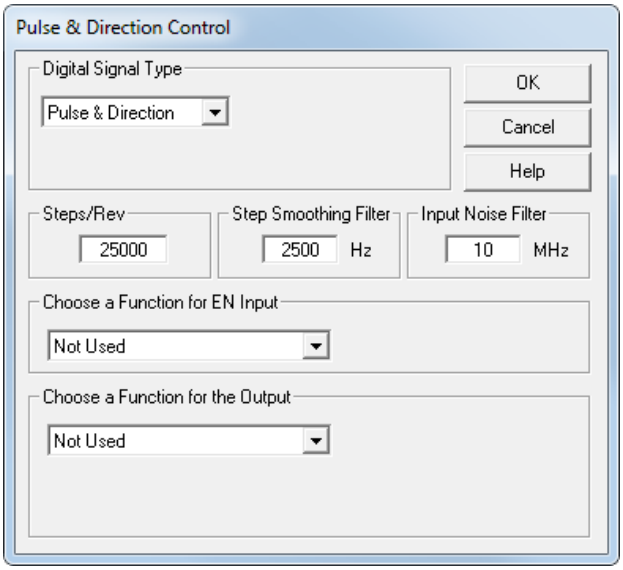
Load Inertia

The NI ISM-7411/7412 includes anti-resonance and electronic damping features which greatly improve motor performance. To perform optimally, the drive must understand the electromechanical characteristics of the motor and load. Most of this is completed automatically in the factory during motor and drive assembly. To further enhance performance, you must specify the innertia of the load. If you are unsure of this value, you can experimentally find an acceptable value by entering a multiplier of the rotor inertia.

Control

From the NI Stepper Configuration Utility home screen, click the **Motion** icon to open the Motion Control Mode Window. Select the **Pulse & Direction Mode** button to configure the following settings:

Figure 28. NI Stepper Configuration Utility Configuration Window



Step Pulse Type

Most indexers and motion controllers provide motion commands in the Pulse and Direction format. The Step signal pulses once for each motor step and the direction signal commands direction. However, a few PLCs use a different type of command signal, CW and CCW Pulse, where one signal pulses once for each desired step in the clockwise direction (STEP CW), while a second signal pulses for counterclockwise motion (STEP CCW). Additionally, the motor can be controlled from the A/B signals of a master encoder, for “follow” applications.

Steps/Rev

The NI ISM-7411/7412 requires a source of step pulses to command motion. This is normally commanded by ENET Control however it can also be commanded by a PLC, indexer, motion controller, or another type of device that can produce step pulses with a frequency proportional to the desired motor speed. The source must also be able to smoothly ramp the step speed up and down to produce smooth motor acceleration and deceleration. This is only a consideration when using a source other than ENET control.

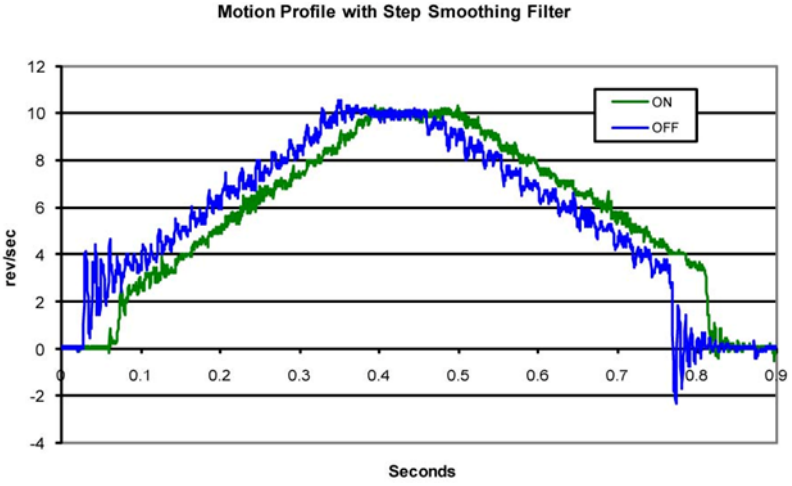
Smaller step sizes result in smoother motion and more precise speed, but also require a higher step pulse frequency to achieve maximum speed. The smallest step size is 1/51,200th of a motor turn. To command a motor speed of 50 revolutions per second (3000 rpm) the step pulse frequency must be 50 × 25,000 = 1.25 MHz. The Steps/Rev value can be entered in any multiple of 2.

Step Smoothing Filter

At lower step resolutions such as 200 steps per revolution (full step) and 400 steps per revolution (half step) motors produce more audible noise than when they are microstepped (2000 steps per revolution and beyond). The NI ISM-7411/7412 includes a feature called microstep emulation, also called step smoothing, that can provide smooth motion when using full and half steps. If the Steps/Rev setting is 2000 or higher, this feature is not needed and can be set to the highest possible value, 2500.

The step smoothing process uses a command filter which causes a slight delay, or lag in the motion. The following figure shows an example of the delay that can occur from using the step smoothing filter.

Figure 29. Delay Due to Filtering



Input Noise Filter

Electrical noise can negatively affect the STEP signal by causing the drive to interpret one step pulse as two or more pulses. This results in extra motion and inaccurate motor and load positioning. To solve this problem, the NI ISM-7411/7412 includes a digital noise filter on the STEP and DIR inputs. The default factory setting of this filter is 7.5 MHz, which is suitable for most applications.

Your maximum pulse rate equals the highest motor speed multiplied by the number of steps per revolution. For example:

$$40\frac{revs}{second} \times 20,000\frac{steps}{revs} = 800kHz$$

Consider the maximum pulse rate when deciding whether you must increase the filter frequency.

EN Input

You can configure the behavior of the EN input. Common applications use EN as a relay to turn the device on and off, or to clear fauls.

Programmable Output

The programmable digital output can be used as an indicator to alert you to faults or to control a brake. It can also be used as a tachometer to report every rotation.

Self Test

If you are having trouble getting your motor to turn, use the built-in self test from the NI Stepper Configuration Utility home page. Select the **Drive** menu item and choose **Self Test**. Use this feature to confirm that the motor is wired correctly, selected, and otherwise operational.

Reference Materials

Torque-Speed Curves

Figure 30. Torque-Speed Curve for NI ISM-7411

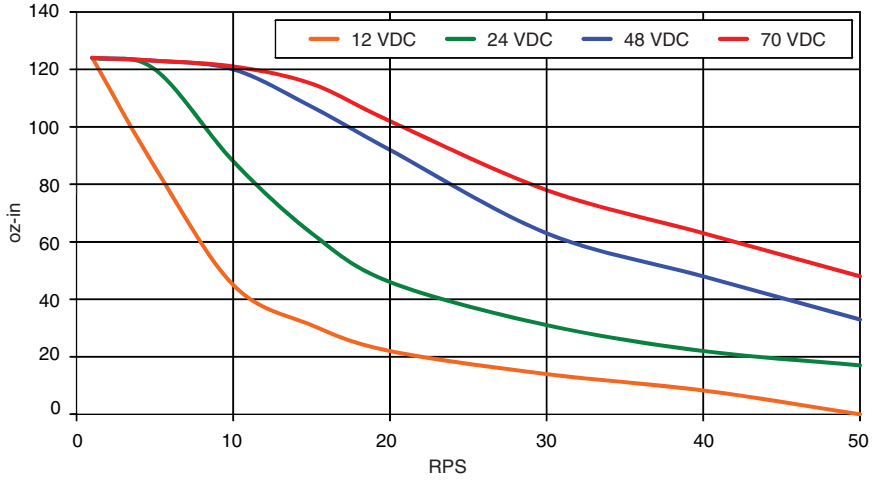
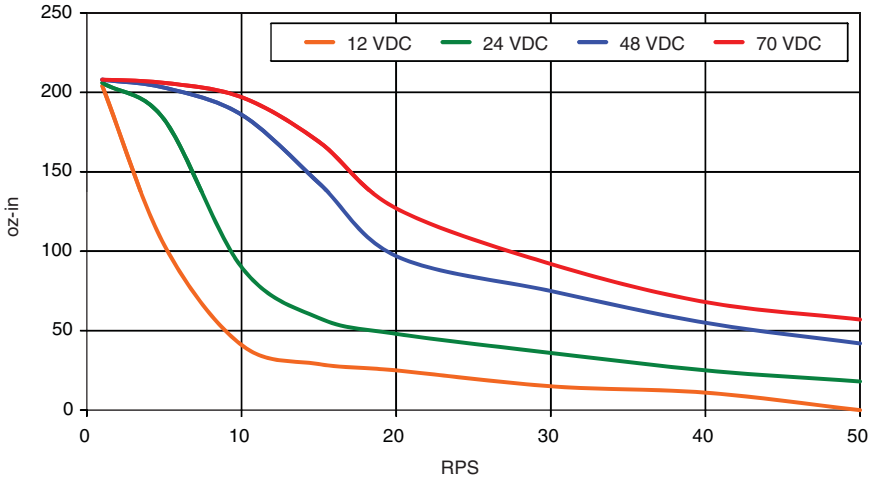


Figure 31. Torque-Speed Curve for NI ISM-7412



Heating

Step motors convert electrical power from the driver into mechanical power to move a load. Because step motors are not perfectly efficient, some of the electrical power turns into heat on its way through the motor. This heating depends on the motor speed and power supply voltage rather than load. There are certain combinations of speed and voltage at which you can continuously operate a motor without damage.

The drive electronics of the NI ISM-7411/7412 also dissipate power. The heat produced by the electronics is dependent on power supply voltage and motor speed.

The following figures show the maximum duty cycle versus speed for the NI ISM-7411/7412 at commonly used power supply voltages. Refer to these curves when planning your application. Use the charts depicting typical power dissipation when planning the thermal design of your application.

A step motor typically reaches maximum temperature after 30 to 45 min of operation. Running the motor for one minute and then idling for one minute results in a 50% duty cycle. Running the motor for five minutes on and five minutes off also results in 50% duty. One hour on and one hour off results in 100% duty because the motor will reach full and possibly excessive temperature during the first hour of use.

Note National Instruments tested the NI ISM-7411/7412 in a 40 °C (104 °F) environment with the motor mounted to an aluminum plate sized to provide a surface area consistent with the motor power dissipation. Your results might vary.

Maximum Duty Cycle

Figure 32. NI ISM-7411 Speed/Duty Cycle Curve

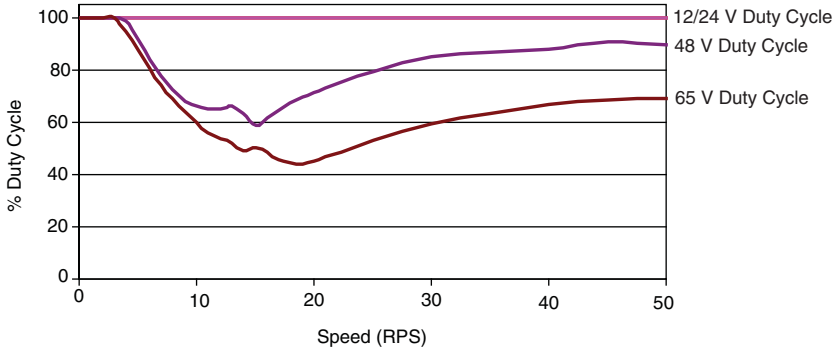


Figure 33. NI ISM-7412 Speed/Duty Cycle Curve

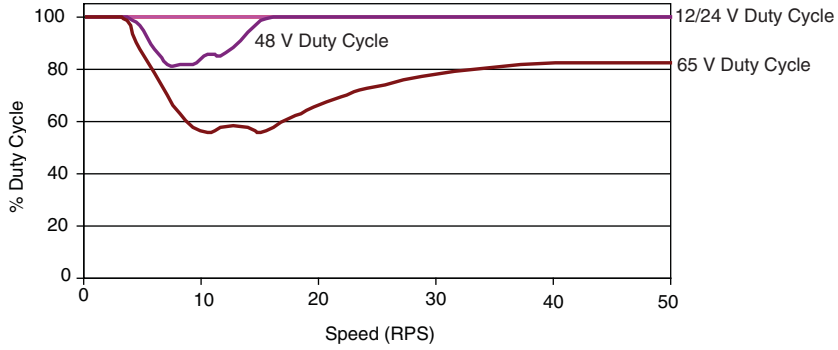


Figure 34. Temperature vs. Speed for the NI ISM-7411

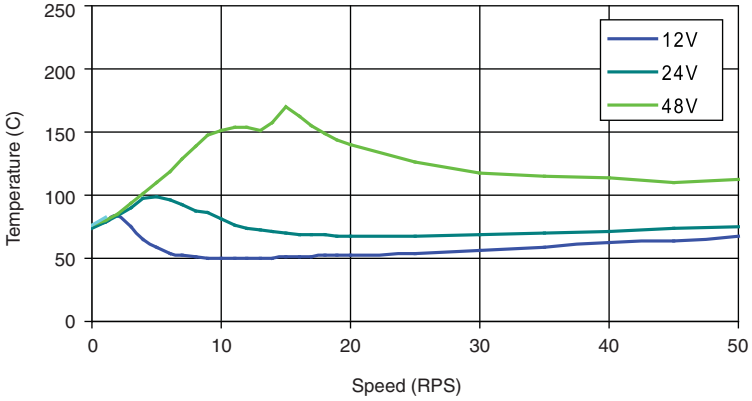


Figure 35. Temperature vs. Speed for the NI ISM-7412

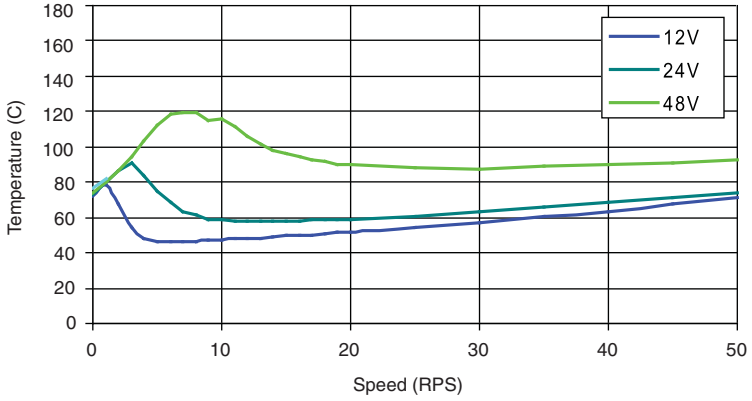


Figure 36. Mechanical Outline for the NI ISM-7411

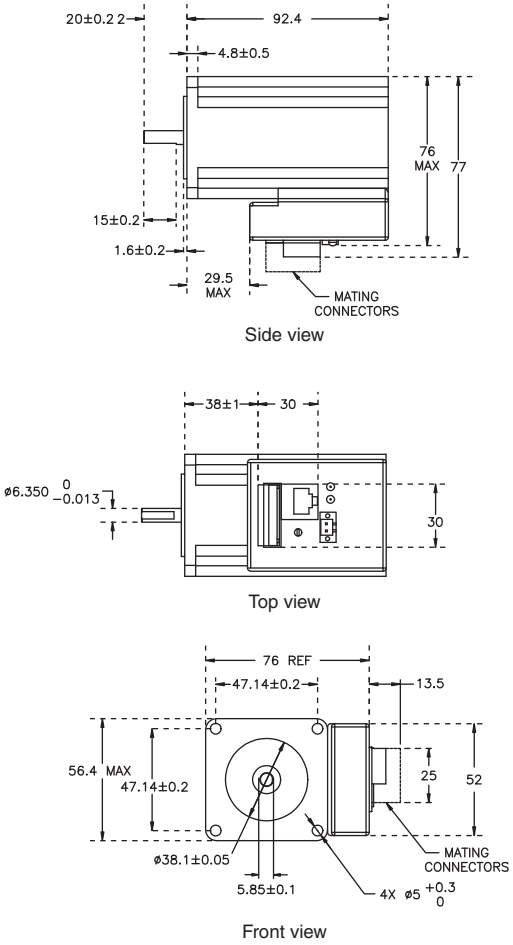
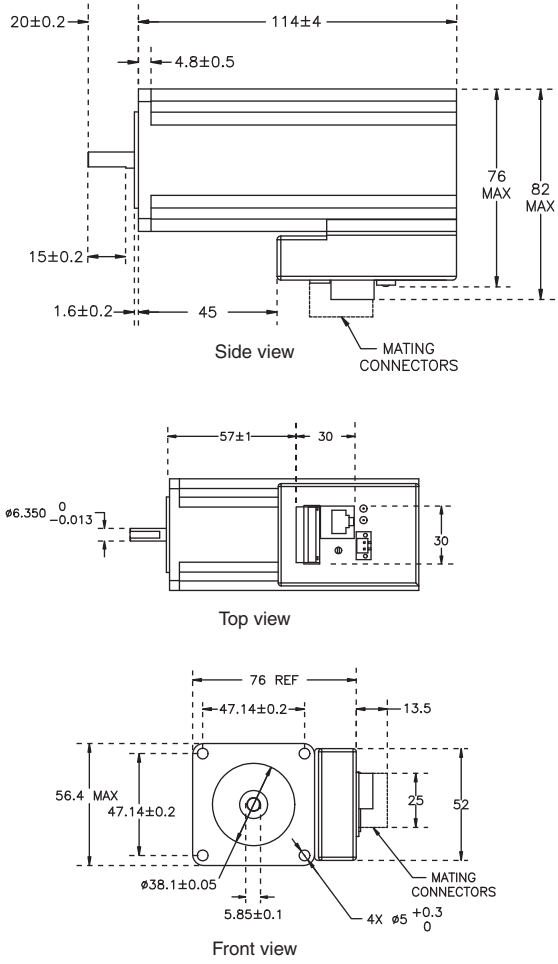


Figure 37. Mechanical Outline for the NI ISM-7412



Technical Specifications

Amplifier

Amplifier type..... Dual H-bridge, 4 quadrant

Current control..... 4 state PWM @ 20 kHz

Protection..... Over-voltage, under-voltage, over-current, over-temperature

Supply voltage ..... 12 VDC to 70 VDC

Under-voltage alarm ..... 11 VDC

Over-voltage shutdown ..... 74 VDC

Over-temp shutdown ..... 85 °C

Motor current ..... 2.5 to 5.0 A/phase peak of sine

Current reduction range ..... 0 to 90%, user configurable

Current reduction delay ..... User configurable

Motor

Torque ..... Refer to *Torque-Speed Curves*

NI ISM-7411 ..... 125 oz-in max

NI ISM-7412 ..... 210 oz-in max

Microstep resolution ..... 200 to 51,200 steps/rev, user configurable

Digital Inputs

Optically isolated, 5 V to 24 V logic. Sourcing, sinking, or differential signals can be used.

Minimum on voltage ..... 4 VDC

Maximum voltage ..... 30 VDC

Maximum pulse frequency: ..... 3 MHz

Minimum pulse width ..... 250 ns

Analog Input

AIN is referenced to GND.

Range ..... 0 to 5 VDC

Resolution ..... 12 bits

Digital Output

Optically isolated, user programmable.

Maximum voltage ..... 30 VDC max

Maximum current ..... 40 mA

+5V User Output

Range ..... 4.8 to 5.0 V

Current ..... 40 mA, max

Physical

Frame size ..... NEMA 23

NI ISM-7411

- Size ..... 2.22 × 3.03 × 3.64 in. (56.4 × 77 × 92.4 mm), not including pilot or shaft. 0.25 in. shaft with flat.
- Weight ..... 30 oz (850 g)
- Rotor inertia ..... 3.68×10^{-3} oz-in.-sec^2 (260 g-cm^2)

NI ISM-7412

- Size ..... 2.22 × 3.23 × 4.49 in. (56.4 × 82 × 114 mm), not including pilot or shaft. 0.25 in. shaft with flat.
- Weight ..... 42 oz (1191 g)
- Rotor inertia ..... 6.52×10^{-3} oz-in.-sec^2 (460 g-cm^2)

Operating temperature range ..... 0 °C to 40 °C

Accessories

Regeneration clamp ..... NI SMD-7700, NI part number 748908-01

Power Supply

- NI PS-12 ..... 24 VDC, 6.3 A, NI part number 748906-01
- NI PS-13 ..... 48VDC, 6.7A, NI part number 748907-01

Alarm Codes

In the event of a drive fault or alarm, the green LED flashes one or two times, followed by a series of red flashes. The pattern repeats until the alarm is cleared.

Table 2. Status LED Blink Code Definitions

Blink sequence	Code	Error
G	Solid green	No alarm, motor disabled
GG (slow)	Flashing green slowly	No alarm, motor enabled
GG (rapid)	Flashing green quickly	Q Program running
RG	1 red, 1 green	Motor stall (encoder-equipped only)
RGG	1 red, 2 green	Move attempted, drive disabled
RRG	2 red, 1 green	CCW limit
RRGG	2 red, 2 green	CW limit
RRRG	3 red, 1 green	Drive overheating

Table 2. Status LED Blink Code Definitions (Continued)

Blink sequence	Code	Error
RRRGG	3 red, 2 green	Internal voltage out of range
RRRRG	4 red, 1 green	Power supply overvoltage
RRRRGG	4 red, 2 green	Power supply underoltage
RRRRRG	5 red, 1 green	Over current / short circuit
RRRRRRG	6 red, 1 green	Open motor winding
RRRRRRRG	7 red, 1 green	Serial communication error

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